Study of Ocean Bottom Interactions With Acoustic Waves by a New Elastic Wave Propagation Algorithm and an Energy Flow Analysis Technique

Ru-Shan Wu
Xiao-Bi Xie
Institute of Tectonics, University of California
Santa Cruz, CA 95064
phone: (831)459-5135 fax: (831)459-2127 email: wrs@es.ucsc.edu
phone: (831)459-5094 fax: (831)459-2127 email: xie@es.ucsc.edu
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http://www.es.ucsc.edu/~act i

LONG-TERM GOAL

Develop a new method and the code to simulate 3D acoustic/elastic wave propagation and interaction with the ocean water and ocean bottom environment. The method will be applied to numerical simulations and imaging to study the wave/sea-bottom interaction, energy partitioning, scattering mechanism and other problems that are crucial for many ocean bottom-surveying techniques. Our understanding on shallow water acoustic wave propagation and its interaction with sediments can be improved.

SCIENTIFIC OBJECTIVES

Improve and develop the ECS (Elastic Complex-Screen), a new one-way elastic wave propagation method, and apply it to the ocean bottom environment to study the elsto-acoustic wave propagation in complex laterally heterogeneous media, including rough interface and random volume heterogeneity.

APPROACH

The basic approach is connection the acoustic phase screen algorithm and elastic complex screen algorithm with a boundary condition, which may permit certain types of roughness. With this method, the acoustic signal can propagate all the way through seawater and solid bottom. Reflections from both water and sub-bottom structures can also be calculated and propagated upward to the surface. A free surface condition can be added at either the source side or receiver side.

WORK COMPLETED

Developed a new version for phase screen method, which can be used for wave propagation at wide angle and under large velocity contrast. We derived the formulas for the new method. We also wrote the code and conducted numerical experiments which applied the new method to both forward modeling and imaging.

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RESULTS

Phase screen method is a high efficient one way wave equation method which can be used either in forward modeling or seismic migration. However, the phase screen method is accurate only for small perturbations or for small incident angles which prevent it from applying to models with large velocity contrasts. In this study, a general formulation of the screen method is derived for wide angle under large velocity contrast. The derivation is based on the plane wave decomposition which avoid the small perturbation assumption. From the general formula, different approaches including the phase screen method and pseudo screen method can be derived under different approximations.

IMPACT/APPLICATION

The phase screen method is based on the one way wave equation method. It can be used as a high efficiency propagator for forward propagation (Wu, 1994; Xie and Wu, 1995, 1996) or seismic migration (Wu and Xie 1994; Huang and Wu, 1996; Wu and Jin, 1997). The derivation of phase screen method usually requires that the velocity perturbation is small or the incident angle is small. However, the real models may contain very large velocity contrasts. The new propagator developed in this study can be directly applied to wave propagation and migration under large velocity perturbations and wide propagation angle.

Numerical tests have been conducted for both forward modeling and imaging (migration). The results show that the new method gives results that much better than that by the conventional phase screen method, and this new method can be a very useful propagator in modeling/imaging where large velocity contrasts exist in the model.

TRANSITIONS

None

RELATED PROJECTS

The ONR supported project is part of researches conducted in the Modeling and Imaging Project (MIP) at University of California, Santa Cruz. The MIP is co-sponsored by DOE, DOD, ONR, AFOSR, GRI, NSF and some industrial companies. The MIP is aiming at developing new theories, methods and algorithms for modeling and imaging in 3D complex environments. This project emphasizes on the fast one-way propagation methods, and also searches for the application of newly developed technologies, such as the wavelet transform, in the wave propagation theory.

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